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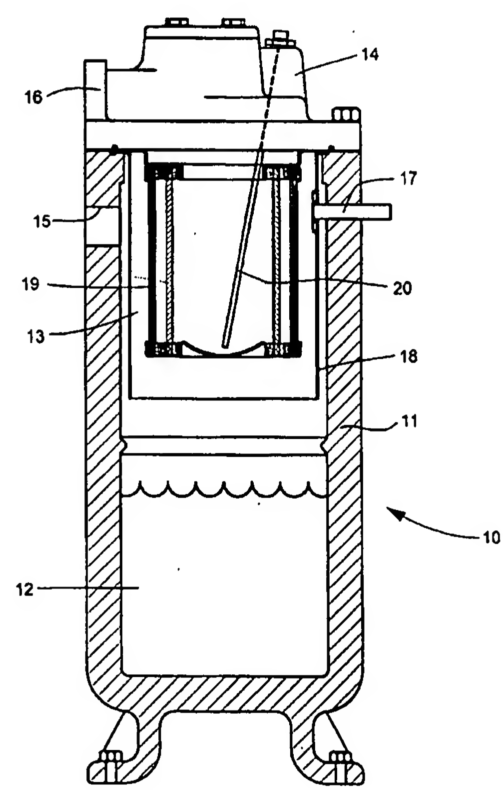
(54) Title: STATIC ELECTRICITY DISSIPATION IN AIR COMPRESSORS

(57) Abstract

The compressor fluid or oil of an air compressor system which is dielectric or electrically insulative is treated with a static dissipative compound to increase its electrical conductivity. The static dissipative compound may be added directly to the compressor fluid, or it may be added by supplying an air-oil separator (13) which is treated or impregnated with the static dissipative compound. The treatment of the compressor fluid reduces the flammability of the compressor fluid by dissipating static electricity build-up.



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STATIC ELECTRICITY DISSIPATION IN AIR COMPRESSORS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to compressor fluids, such as those used in air compressor systems, and in particular to the dissipation of static electricity in such fluid.

2. Description of the Prior Art

Air compressors and other similar compressors, such as vacuum compressors and refrigerant compressors, use a liquid fluid for cooling, sealing and lubrication. Although this fluid is commonly referred to as "oil," it is more properly a specially selected organic liquid chosen primarily for its heat exchange characteristics, viscosity and lubricity. Examples of fluids used as oil in air compressor systems include polyalphaolefin (PAO), polypropylene glycol, polyolester (POE), diester-based oil, combinations of PAO and diester fluid, petroleum-based fluid, silicon-based oil and severely hydro-treated paraffinic oil. Many of these fluids have found use in compressor systems after being developed for other applications, such as hydraulic fluid for hydraulic systems.

Some of these fluids, particularly the PAO fluids, were originally used as coolants in electric transformers. The heat exchange characteristics of PAO fluids exhibited as a transformer coolant made these fluids a popular choice for adoption as

oil in air compressors. where they are commonly used today. Because of their development for use in electrical transformers. these fluids are dielectric fluids. that is, fluids which act as an electrical insulator and prevent any transfer of electricity. PAO fluids are sold for use in air compressors under various brand names. including: Sullube 32. sold by Sullair Corporation of Michigan City. Indiana: AEON 9000. sold by Gardner Denver. Inc. of Quincy. Illinois: Quin-Syn series. sold by Quincy Compressor Division of Coltec Industries of Quincy. Illinois: and Roto Inject fluid. sold by Atlas Copco Air Power of Wilrijk. Belgium.

The compressor fluid or oil is used not only for sealing and cooling but also for lubrication. and for this purpose some of the oil becomes suspended in the air stream. Air-oil separators are typically used to remove suspended oil mist from the air stream before the compressed air is discharged. The separator allows the discharged air to be used without the contamination of oil and provides for the recovery of the oil so that it can be reused. The air-oil separator is typically mounted in a housing or tank having a separation chamber through which the air flows above an oil reservoir. The separator includes coalescing media through which the discharge air passes while the oil is separated from the air flow. The coalescing media is cylindrically shaped and is typically mounted vertically, that is, in which the axis of the cylindrical coalescing media extends in a vertical direction. The oil-laden air usually enters the separation chamber from outside the air-oil separator and flows into the center of the separator where it then flows axially out of the separation chamber. As the air flows radially through the layers of the separator, the oil coalesces and collects in the interior of the separator where it can be syphoned off or drained into the reservoir, typically by means of a scavenging system, so that it can be reused. The flow directions may also be reversed in which the oil-laden air is introduced into the center of the air-oil separator and flows radially outwardly through the separator with the oil coalescing and collecting on the outside of the separator where it drains into a reservoir.

Since fluids such as PAO are electrically nonconductive, static electric charges are prone to build up on the bulk oil as well as the atomized oil that is entrained in air flow. The fluid is subjected to extreme high shear in the compressor chamber, causing this build-up of static electricity. Because the fluid is dielectric, this static charge will remain in the fluid, even if the walls and other metal components of the compressor in contact with the fluid are grounded. The combination of a static electricity build-up along with the potential high temperatures and readily supply of combustion air creates a situation in which the discharge air may become highly flammable. The flammability of the mixture is particularly evident in and around the air-oil separator and the reservoir tank.

SUMMARY OF THE INVENTION

The present invention provides for addressing the problem of static electricity build-up in the oil in air streams of air compressor systems by providing for the dissipation of static electricity in the compressor fluid. In accordance with the present invention, the compressor fluid is treated with an electrically static dissipative compound, making the compressor fluid less susceptible to static electricity build-up, and thus reducing or dissipating the potential static charge in the compressor air stream before it reaches a potentially flammable and dangerous condition.

According to the present invention, the electrically static dissipative composition may be added to the compressor fluid in several ways. The static dissipative composition may be added directly to the compressor fluid or oil already in the compressor, increasing the electrical conductivity of the suspended mist of oil in the air stream and dissipating any static charge in the air stream before it reaches potentially dangerous levels. Alternatively, the air-oil separator may be coated or impregnated with the electrically static dissipative composition. This composition

would then leach out into the compressor fluid as the fluid is being separated from the air steam and returned to the reservoir, thereby treating the compressor fluid with the static dissipative compound. In addition, the coating or impregnation of the air-oil separator with the composition would render the air-oil separator more conductive itself, and, if the separator is properly grounded, provide added safety in the reservoir tank. As a further alternative, a compressor fluid which is dielectric, such as those comprising primarily PAO, could be treated with the static dissipative compound during its manufacture, so that when the compressor fluid is replaced by the user, the new fluid has increased conductivity.

These and other advantages are provided by the present invention of a method of operating an air compressor, which comprises the steps of providing a discharge air stream; using an electrically insulative compressor fluid for cooling and lubrication, droplets of such fluid being suspended in the air stream; and treating the compressor fluid by adding a static dissipative compound to the fluid to increase the electrical conductivity of the fluid and prevent excessive static charge build-up, the addition of the compound changing the droplets in the air stream from insulative to static dissipative.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view, partially in section, of an oil reservoir tank assembly with an air-oil separator which may be used as part of the present invention.

FIG. 2 is side elevational view of an oil filter for an air compressor system which may be used as part of the present invention.

FIG. 3 is an end elevational view of the oil filter of FIG. 2.

FIG. **4** is a graph showing the conductivity effect of various concentrations of an anti-static agents in air compressor fluid.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawings and initially to FIG. **1**, there is shown an oil tank assembly **10** for use in an air compressor. The tank assembly shown and described herein is typical. but it is only one of many arrangements which may be used. The tank assembly **10** comprises a body **11** having a reservoir **12** formed at the bottom for collection of the compressor fluid or oil removed by in the oil separation process. The upper portion of the body **11** forms a separation chamber **13**. The top of the separation chamber **13** is enclosed by a tank cover **14** which is attached to the body **11** by a plurality of bolts or other suitable fastening devices with a tank seal or gasket provided between the body and the tank cover. An air inlet **15** is provided on one side of the body **11** for air to enter the separation chamber **13**. The air flows from the separation chamber through a passage (not shown) in the tank cover **14** and through an air outlet **16** provided in the tank cover.

Within the separation chamber **13** may be a pre-separation configuration, such as a generally cylindrical shroud **18** which diverts the incoming air flow from the air inlet **15** and causes the air to flow down and around the shroud. This provides a first stage air-oil separation, in that, large droplets of oil are separated by the abrupt change in air flow and these oil droplets fall into the reservoir **12**. Other known pre-separation configurations may be used in place of the shroud **18**. A safety valve **17** is also provided in the body **11** extending through the shroud **18**. The safety valve **17** is a pressure relief valve which opens in the event that air pressure inside the shroud **18** increases above a predetermined level. The air flow then passes upwardly

and axially inwardly, through an air-oil separator **19**. The separator **19** typically comprises two or more coaxially arranged layers, including an upstream coalescing stage layer and a downstream drain stage layer, each comprised of any suitable combination of materials used in air-oil separation, such as fiberglass, polyester, polypropylene or metal, some of which may be pleated in a conventional manner, or which may be molded, formed, wrapped or otherwise shaped. The air-oil separator **19** also preferably includes an outer wrap layer on the exterior of the separator, and a support member along the interior surface. Each end of the layers are set in a hardenable sealing or potting material, such as urethane, epoxy or plastisol, to make generally circular end caps, usually with metal backing, in accordance with conventional air-oil separator design.

A scavenging tube **20** extends downwardly from the tank cover **14** into the separation chamber inside the separator **19**. Oil draining from the separator **19** can be withdrawn therefrom using the scavenging tube **20**.

The compressor fluid or oil which is stored in the reservoir **12** and used in the air compressor is a liquid which may consist primarily of polyalphaolefin (PAO), a substance which is dielectric, that is, nonconductive or insulative, and which was developed for use in cooling electrical power transformers. As used herein, the terms "conductive," "static dissipative" and "insulative" have generally the same meaning as defined by the Electrostatic Discharge Association (ESD Association) of Rome, New York. A material or substance which is considered to be "conductive" has a conductivity of less than 10^5 ohms per square unit of surface area. A material or substance which is considered to be "static dissipative" has a conductivity of 10^5 to 10^{12} ohms per square unit of surface area. A material or substance which is considered to be "insulative" has a conductivity of greater than 10^{12} ohms per square unit of surface area. Compressor fluids such as those which are PAO-based fluids fall within this "insulative" range. Therefore, the small droplets or mist of the

compressor fluid or oil suspended in the compressor air stream is prone to the build-up of a static charge. The insulative properties of the oil keep this static charge from dissipating. As the air is acted upon by the compressor, the static charge builds up along with the temperature of the air, and the air stream becomes highly combustible.

In accordance with the present invention, this compressor fluid or oil is treated with a liquid which is an electrically static dissipative compound, or anti-static agent, bringing the compressor fluid, including the fluid suspended in the air stream, from the "insulative" range to the "static dissipative" range, and dissipating static electricity charges which might otherwise build-up. An example of such a compound is a product sold under the trademark Staticide and available from ACL Incorporated of Elk Grove, Illinois. This product is an anti-static polymeric composition. Other suitable static dissipative compounds or anti-static agents may be used.

The treatment of the oil may be accomplished in several different ways.

During its manufacture or thereafter, one or more of the layers of the air-oil separator **19** may be coated or impregnated with the electrically static dissipative compound. If a sufficient amount of the static dissipative compound is impregnated into the separator **19**, it will slowly leach out into the fluid. Since the separator **19** is changed at regular intervals in most compressor systems, each new separator will bring a new supply of the static dissipative compound which will continue to treat the compressor fluid. The separator would thus act as a dispenser, dispensing an electrically dissipative compound into the compressor fluid over a period of time to constantly treat the compressor fluid and make the fluid more electrically dissipative. By the time that the compound has fully leached from the separator, the separator would be ready for replacement, so that a new supply of the compound would be available to leach into the compressor fluid supply.

Coating or impregnation of the static dissipative compound may also make the air/oil separator itself more electrically dissipative. Thus, any remaining static charges which may build up on the treated oil droplets will be dissipated when the oil

encounters the electrically conductive separator **19**. In order to take advantage of this effect, the separator itself must be electrically conductively mounted in the tank assembly. In other words, the separator must be grounded. It has been known to electrically ground air-oil separators by providing metal staples in the rubber gaskets. However, this process may adversely effect the effectiveness of the gaskets. It is preferred to coat the rubber seal or urethane potting compound which is used to hold the ends of the separator layers with the static dissipative material. In this manner, the entire separator **19** may be grounded to the body of the tank assembly, which is itself grounded. The static dissipative material could be coated onto the gasket or urethane potting layer, or it could be mixed with the urethane prior to the curing of the urethane, making the urethane static dissipative, by reducing the resistance of the urethane to, for example, 10^5 to 10^9 ohms.

Instead of the air-oil separator, the oil filter can also be used as a dispenser for the electrically static dissipative material. An example of an oil filter used in an air compressor is shown in the oil filter **21** of FIG. **2**. The oil filter **21** is a spin-on filter having a rugged external casing **22** and an internal thread **23** at one end separating two concentric channels **24** and **25** used for the oil inlet and outlet. The filter **21** is mounted by its threaded connection **23** to the oil supply on or near the reservoir **12**. Inside the casing **22** is one or more layers of filter media **26**, each comprised of any suitable combination of materials used in oil filtering, such as fiberglass, polyester, polypropylene or metal, some of which may be pleated in a conventional manner, or which may be molded, formed, wrapped or otherwise shaped. One or more these layers may be coated or impregnated with the static dissipative compound. If a sufficient amount of the static dissipative compound is impregnated into the oil filter **21**, it will slowly leach out into the oil. Since the oil filter **21**, like the separator **19**, is changed at regular intervals in most compressor systems, each new separator will bring a new supply of the static dissipative compound which will continue to treat the

oil. The oil filter would thus also act as a dispenser for the electrically dissipative compound. By the time that the compound has fully leached from the oil filter, the filter would be ready for replacement, so that a new supply of the compound would be available to leach into the oil supply.

In addition to treating existing fluid, either by adding the electrically dissipative compound to the fluid directly or though leaching from the air-oil separator, the compressor fluid may be treated with the additive initially during its manufacture, so that the amount of anti-static additive will not be dependent upon the amount of material added to the fluid in use. Treating the compressor fluid initially may be preferred in new systems or when the compressor fluid is completely replaced in an existing system.

The result of adding the electrically static dissipative compound or anti-static agent to compressor fluid is to increase significantly the electrical conductivity of the fluid. Tests have been conducted using a commonly used commercial PAO-based compressor fluid, and adding various levels of a static dissipative agent to the fluid. The electrical conductivity of the fluid was then measured using the standard test method ASTM D 4308, which applies to the determination of the electrical conductivity of aviation fuels and other similar low-conductivity hydrocarbon liquids in the range of 0.1 to 2000 picosiemens per meter (pS/m). Picosiemens per meter (pS/m) is the common unit of electric conductivity, with a siemen being the reciprocal of an ohm.

$$1 \ \mathrm{pS/m} = 1 \times 10^{-12} \ \Omega^{-1} \ \mathrm{m}^{-1}$$

Various concentrations of three different static dissipative additives, one of which was Staticide, were added to the commonly used commercially available PAO-based compressor fluid, and the conductivity of the fluid was measured according to the ASTM D 4308 test standard. The results of these tests, with the concentration of the

static dissipative agents shown in parts per million (ppm), are shown in the following table and in FIG. 4.

Concentration of Additive (ppm)	Fluid Conductivity (pS/m)		
	Additive A	Additive B	Additive C
10	6	83	17
100	12	331	53
500	25	862	96
1,000	49	1997	121

The test results show that the typical PAO-based compressor fluid by itself is insulative, having very low measurements of conductivity. The addition of an static dissipative agent, such as Staticide, significantly increases the conductivity of the compressor fluid. The addition of relative small amounts of the additive can change the compressor fluid from "insulative" to "static dissipative" as defined above. The increased conductivity of the compressor fluid with the added static dissipative additive can be compared to the desired electrical conductivity for aviation turbine fuels which should be 50 to 450 pS/m to prevent static charge flammability problems in fuel tanks. By raising the conductivity of the fluid to 1 pS/m, the fluid becomes "static dissipative." Preferably, the conductivity of the fluid is raised to 50 pS/m or higher by the addition of the additive in order for the fluid to have sufficient static dissipative properties that dangerous levels of static charge build-up are avoided. It can be seen that such levels of electrical conductivity can be achieved with the addition of small levels of an anti-static agent to compressor fluids.

Other variations and modifications of the specific embodiments herein shown and described will be apparent to those skilled in the art, all within the intended spirit and scope of the invention. While the invention has been shown and described with

respect to particular embodiments thereof, these are for the purpose of illustration rather than limitation. Accordingly, the patent is not to be limited in scope and effect to the specific embodiments herein shown and described nor in any other way that is inconsistent with the extent to which the progress in the art has been advanced by the invention.

CLAIMS

What is claimed is:

1. A method of operating an air compressor, which comprises the steps of:

providing a discharge air stream;

using an electrically insulative compressor fluid for cooling and lubrication, droplets of such fluid being suspended in the air stream; and

treating the compressor fluid by adding a static dissipative compound to the fluid to increase the electrical conductivity of the fluid and prevent excessive static charge build-up, the addition of the compound changing the droplets in the air stream from electrically insulative to static dissipative.

2. A method of operating an air compressor as in claim **1**, wherein the addition of the static dissipative compound changes the compressor fluid to a conductivity of at least 1 pS/m.

3. A method of operating an air compressor as in claim **2**, wherein the addition of the static dissipative compound changes the compressor fluid to a conductivity of at least 50 pS/m.

4. A method of operating an air compressor as in claim 1, wherein the compressor fluid has a conductivity of less than 1 pS/m prior to treating the fluid with the static dissipative compound.

5. A method of operating an air compressor as in claim 1, wherein the compressor fluid which is provided is a polyalphaolefin based fluid.

6. A method of operating an air compressor as in claim 1, wherein the treating step comprises the addition of Staticide to the fluid.

7. A method of operating an air compressor as in claim 1, wherein the fluid is treated by impregnating an air-oil separator with the static dissipative compound and allowing the compound to leach out into the fluid as the fluid is separated from the air stream by the separator.

8. A method of operating an air compressor as in claim 1, wherein the fluid is treated by impregnating an oil filter with the static dissipative compound and allowing the compound to leach out into the fluid as the fluid is filtered.

9. A method of operating an air compressor, which comprises the steps of:

providing a discharge air stream;

using an electrically insulative compressor fluid for cooling and lubrication, droplets of such fluid being suspended in the air stream;

using an air-oil separator to remove the suspended droplets from the air stream for reuse; and

treating the compressor fluid by adding a static dissipative compound to the fluid to increase the electrical conductivity of the fluid and prevent excessive static charge build-up, the addition of the compound changing the droplets in the air stream from insulative to static dissipative.

10. A method of operating an air compressor as in claim **9**, wherein the fluid is treated by impregnating the air-oil separator with the static dissipative compound and allowing the compound to leach out into the fluid as the fluid is separated from the air stream by the separator.

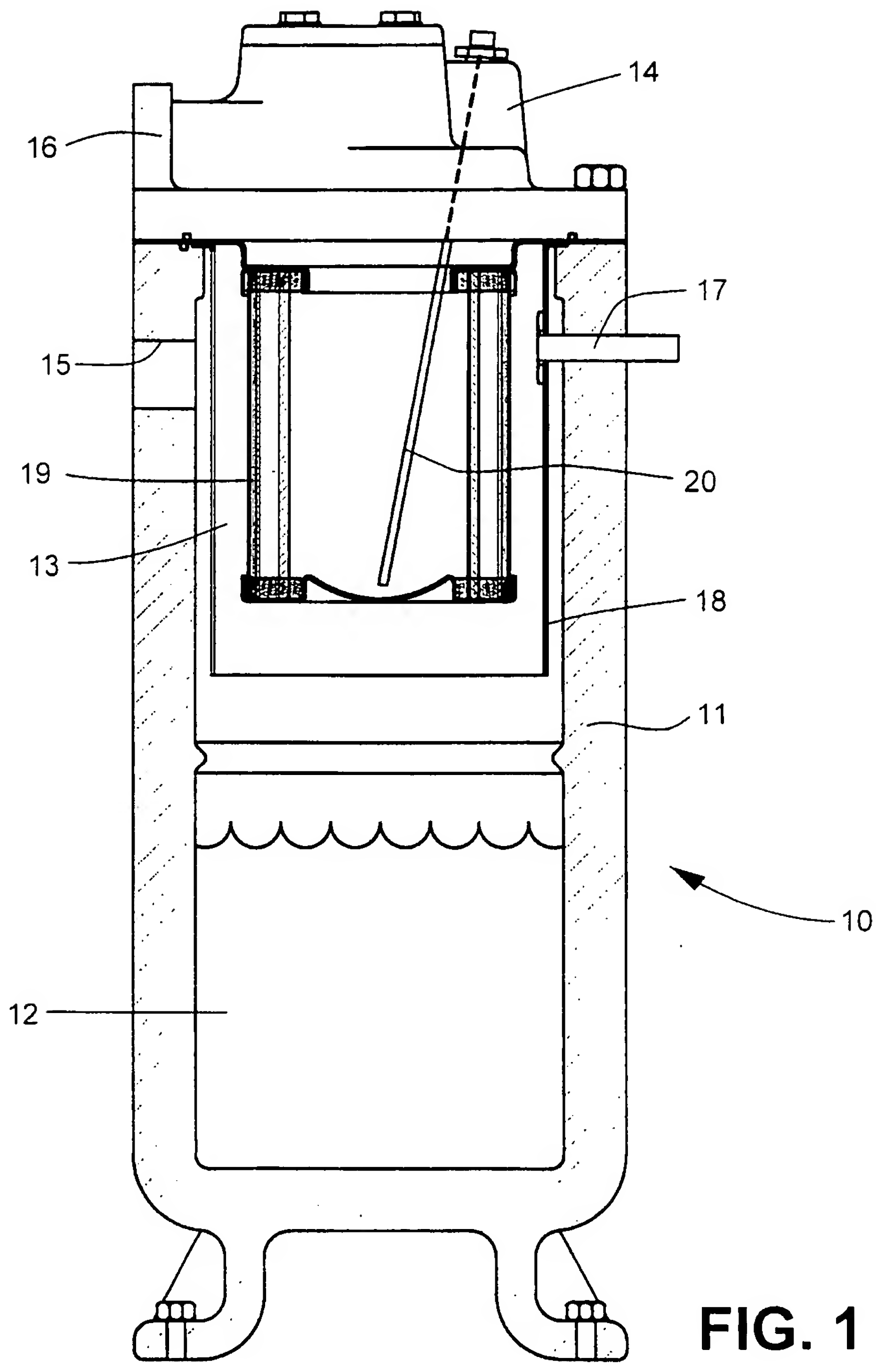

FIG. 1

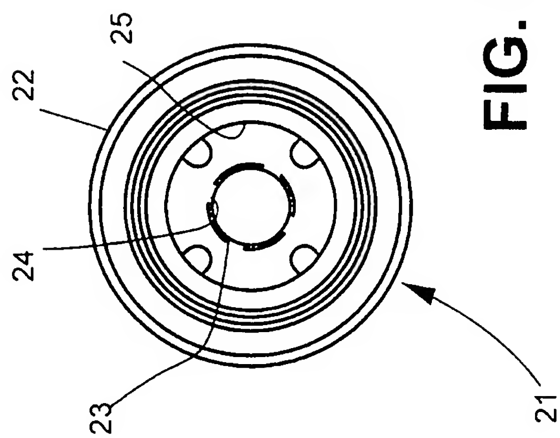

FIG. 3

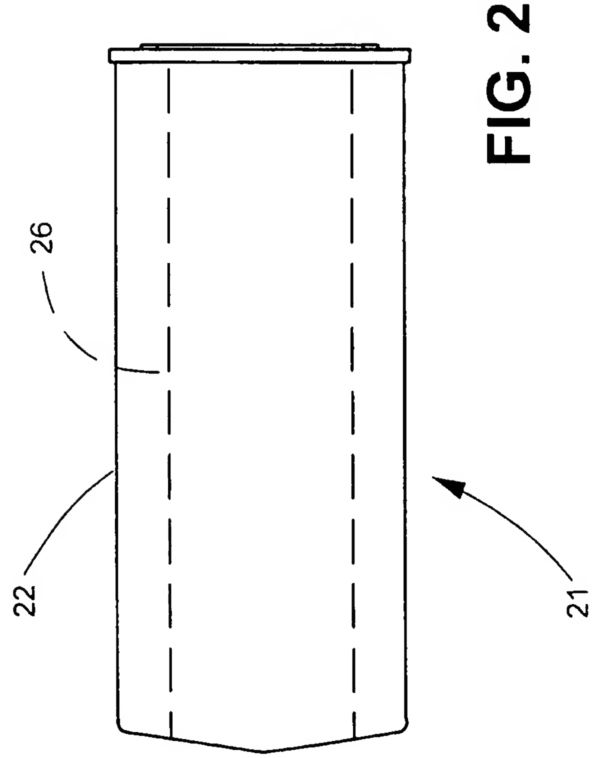

FIG. 2

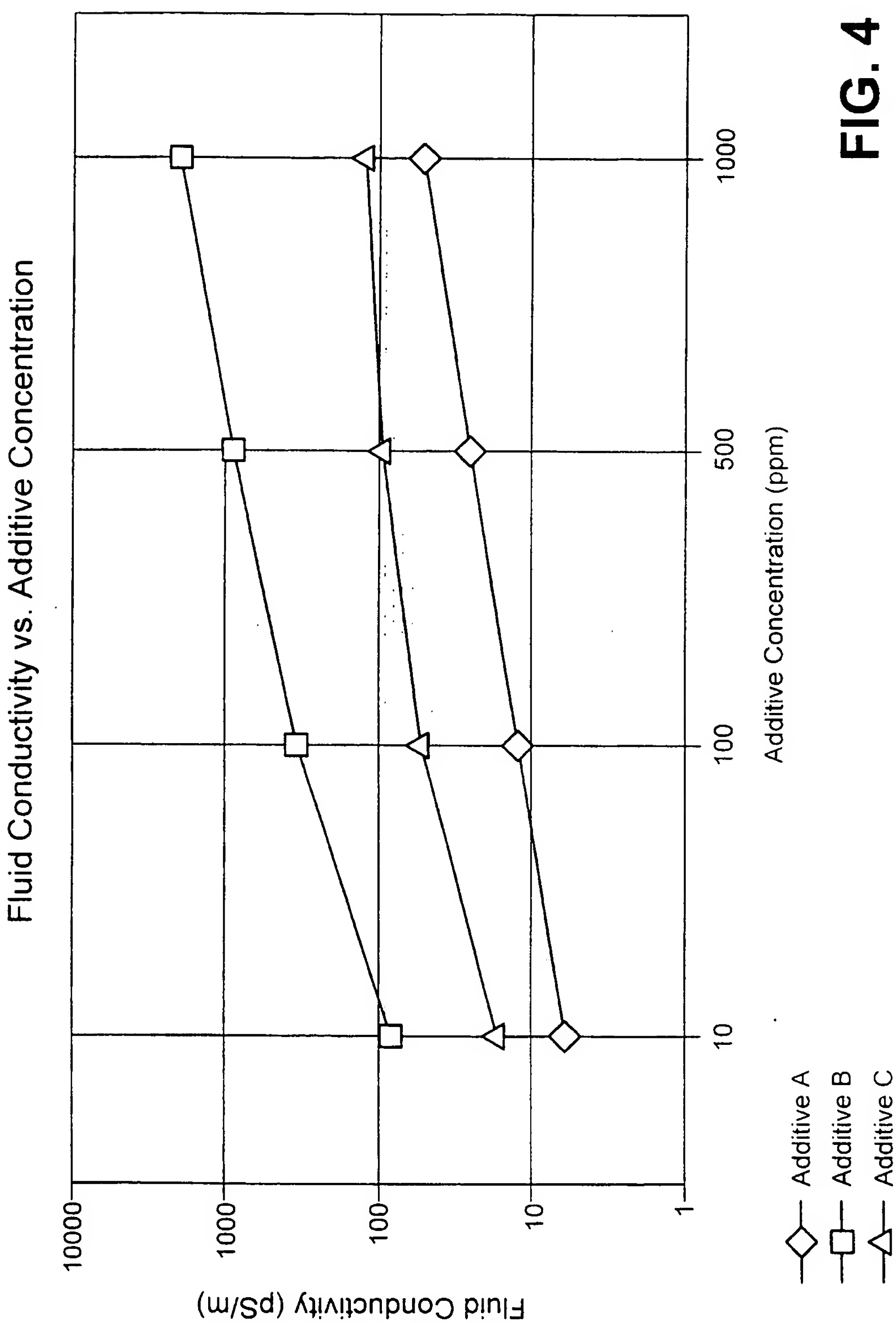
Fluid Conductivity vs. Additive Concentration
Fluid Conductivity (pS/m)
10000
1000
100
10
1
10
100
500
1000
Additive Concentration (ppm)
Additive A
Additive B
Additive C

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/05744

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A62C 39/00
US CL :169/45
According to International Patent Classification (IPC) or to both national classification and IPC

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U.S. : 169/45,46,54; 418/DIG 1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,099,976 A (JAMISON) 31 March 1992, see column 7 lines 1-16.	1-10
A	US 4,378,920 A (RUNNELS et al) 05 April 1983, note the separator 118 that removes combustible oxygen from the air.	1-10
A	US 4,378,851 A (DEVRIES) 05 April 1983, see the entire document which describes impregnating flowing air with water droplets to prevent combustion.	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 MAY 1999	18 JUN 1999

Name and mailing address of the ISA/US	Authorized officer
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